

WORKING DRAFT of Ecological Effects Subcommittee

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12-8-04

Charge Question 18. Does the Council support the plans in chapter 7 for: (a) qualitative characterization of the ecological effects of Clean Air Act-related air pollutants, (b) an expanded literature review, and (c) an quantitative, ecosystem level case study of ecological service benefits? If there are particular elements of these plans which the Council does not support, are there alternative data or methods the Council recommends?

The ecological effects subcommittee (EES) strongly supports the Council's plans for: (a) qualitative characterization of the ecological effects of Clean Air Act-related air pollutants, (b) an expanded literature review, and (c) an quantitative, ecosystem-level case study of ecological service benefits. There is increasing recognition of the value of ecosystem functions and services. The importance of some of these functions and services have been long acknowledged, such as the supply of abundant, clean water, forest biomass production, fisheries habitat and support of recreation. Other processes and phenomena, such as the regulation of trace gases or biological or landscape diversity, are more subtle and their link to human welfare is only starting to be understood.

Research over the past few decades has established that air pollutants can affect the structure and function of ecosystems, which in turn can alter ecosystem services. Many important air pollutants are regulated under the Clean Air Act, such as nitrogen oxides, sulfur dioxide and certain hazardous air pollutants (HAPS; e.g., benzene; mercury). Other air pollutants such as ammonia and carbon dioxide have clear effects on ecosystem functions and services but are not addressed in the Clean Air Act. There are many examples of significant effects of air pollution on ecosystems. Elevated emissions and atmospheric deposition of nitrogen contribute to the over-enrichment of coastal waters. This disturbance can reduce submerged aquatic vegetation and dissolved oxygen, diminishing recreational and commercial fisheries. Atmospheric deposition of sulfur and nitrogen can acidify base-poor soils and waters in high elevation forested regions. These inputs can decrease species diversity and the abundance of sensitive species in both terrestrial and aquatic ecosystems, altering recreational opportunities and possibly impacting forest productivity. Atmospheric deposition of mercury can contaminate consumable fisheries.

It is difficult to quantify ecological service benefits. Nevertheless, the EES believes an expanded literature review and a case study (or case studies) of ecological service benefits would be important undertakings. These activities would help serve notice of the importance of ecosystem service benefits and could provide a foundation for future advances to quantify the complete benefits associated with air pollution control programs.

Charge Question 19. Initial plans described in chapter 7 reflect preliminary EPA decision to base the ecological benefits case study on Waquoit Bay in Massachusetts. Does the Council support these plans? If the Council does not support these plans, are there alternative case study designs the Council recommends?

The EES supports the EPA's plans to conduct a quantitative ecological benefits case study. However, we have some reservations with focusing this initiative on Waquoit Bay, MA. Waquoit Bay is small and relatively homogenous, and there is considerable information on the long-term inputs of nitrogen and effects on the ecosystem (see below). In this regard, it would be relatively easy to conduct a quantitative case study on Waquoit Bay. However, there are some disadvantages with solely relying on Waquoit Bay as a case study. Because Waquoit Bay is small it is probably not representative of coastal ecosystems and their associated functions and services in the U.S. Although atmospheric deposition is an important input of nitrogen to Waquoit Bay, it is not the largest input. Indeed nitrogen associated with treated wastewater is the largest input and there are also large inputs associated with fertilizer application. The EES has concerns that it would be difficult to quantify the specific contribution of regulated atmospheric nitrogen deposition (e.g., nitrate originating from regulated emission sources) to the benefits of the Waquoit Bay ecosystem. Finally, the EES believes by solely conducting a case study on Waquoit Bay, or an other coastal ecosystem, an opportunity is lost to consider the benefits service benefits associated with control of two or more air pollutants simultaneously, such as are being currently considered with proposed multi-pollutant legislation (i.e., sulfur, nitrogen, mercury). The EPA could conceivably consider the benefits of nitrogen and mercury controls to a coastal ecosystem, such as Waquoit Bay, but the processes regulating mercury concentrations in fish in estuaries are not well established.

The EES recommends that the Council and the EPA consider conducting two case, possibly one involving a coastal ecosystem, such as Waquoit Bay and a second involving an upland region. In this regard we have summarized below several possible regions where case studies quantifying benefits ecosystem services associated with air pollution control might be conducted. Several of the upland regions discussed provide the opportunity to examine the effects of control of multiple pollutants individually or simultaneously.

Gulf of Mexico – Ollinger

The Gulf of Maine (GOM) watershed includes several large river basins located across eastern New England and maritime Canada with a total land area of approximately 177,000 km². Major rivers within New England include the Merrimack, Saco and Kennebec/Androscoggin systems in Massachusetts and Maine. The region is heavily forested with increasing population densities along immediate coastal areas and towards the Boston Metropolitan area to the south. Links between nitrogen pollution and harmful algal blooms have been a cause for concern, particularly in southern portions of the Gulf. Although the largest single source of N to the coastal zone is inflow from the open ocean, runoff derived from atmospheric deposition is the next largest source in most sub-basins (with the exception of urban areas near Boston).

Several organizations are involved in either monitoring environmental parameters relevant to GOM marine ecosystems or in distributing data from research and monitoring efforts. These include the Gulf of Maine Ocean Observing System (<http://www.gomoos.org/>), the Center for Coastal Ocean Observation and Analysis (<http://www.ccoa.sr.unh.edu/>) and the WebCoast data retrieval system (<http://webcoast.sr.unh.edu/home.jsp>).

Long Island Sound – Driscoll

Table 1. Qualitative evaluation rating for Long Island Sound.

1. Well-documented impacts to a particular ecosystem function or service:	
	yes
a.	impacts (specify): eutrophication; loss of submerged aquatic vegetation and decreases in dissolved oxygen; decreases aquatic habitat
b.	level of degradation (specify severe, moderate, mild): moderate
c.	importance of atmospheric deposition source (specify % and other sources): 20-30%; major inputs from other nitrogen sources, particularly treated wastewater
2. Quantifiable endpoints (also specify data sources, if possible)	
a	ecological (specify): loss of aquatic habitat
b	economic (specify): loss of recreational and commercial fisheries;
3. Available monetary values for at least some endpoints (if available):	
	Yes the State of Connecticut conducted a cost analysis for removing nitrogen in wastewater.
4. Take advantage of existing initiatives to maximize use of available resources, avoid redundant research, and demonstrate multiple applications of ongoing project; yes – there is considerable work going on be the States of Connecticut and New York	

Barnaget Bay - Castro

Adirondacks – Driscoll

The Adirondack region in northern New York State is a large (2,400,00 ha) forested area, ranging in elevation from 30 to 1,630m. It is underlain by bedrock composed primarily of granitic gneisses and metasedimentary rocks which are generally resistant to chemical weathering. Surficial materials are primarily the result of glacial activity. Soils are generally developed from glacial till, and are shallow and acidic. There are approximately 2,800 lakes in the Adirondacks (with surface area > 0.2 ha). The region receives elevated inputs of acidic deposition of nitrate, sulfate and mercury (Table 1) and probably exhibits the most severe ecological impacts from acidic deposition of any region in the U.S. For example in a survey of 1469 lakes during 1984-87, 27% were chronically acidic (i.e., acid neutralizing capacity (ANC) < 0 µeq/L; Baker and Gherini 1990). An addition 21% had summer ANC values between 0-50 µeq/L and could experience hydrologic events which decrease ANC values near or below 0 µeq/L. Decreases in pH and elevated concentrations of aluminum have reduced species diversity and abundance of aquatic life in many lakes and streams in the Adirondacks. Fish have received the most attention to date, but entire food webs are often adversely affected. There is also apparently a linkage between acidic deposition and fish mercury contamination (Driscoll et al. 1994).

Table 2. Summary of the pH of wet deposition, and wet deposition of sulfate and nitrate for long-term precipitation chemistry station in the Adirondacks (1998-2000).

Site	PH	Sulfate (kg SO ₄ /ha-yr)	Nitrate (kg NO ₃ /ha-yr)
Huntington Forest	4.50	14.0	13.9
Whiteface Mt.	4.56	14.8	13.8

Effects of acidic deposition are less well documented for terrestrial ecosystems. Nevertheless it appears that acidic deposition has resulted in: 1) elevated accumulation of sulfur and nitrogen in soil, 2) depletion of available pools of nutrient cations (i.e., calcium, magnesium), and 3) the mobilization of aluminum from soil (Driscoll et al. 2001). The long-term impacts of these perturbations are not clear but recent studies suggest linkages to the decline of sensitive tree species such as red spruce and sugar maple.

Recently Banzhaf et al. (2004) conducted a study on valuation of natural resource improvements in the Adirondacks. Based on their estimates of willingness to pay benefits in New York State to reductions in acidic deposition in the Adirondacks range from \$336 million to \$1.1 billion per year.

There have been numerous assessments of the effects on acidic deposition on the Adirondacks (Baker et al. 1990; Driscoll et al. 1991; Wigington et al. 1996; Sullivan 1997; Driscoll et al. 2001). Numerous groups continue to conduct research and assessments on the effects of air pollution in the Adirondack region, including the New York State Department of Environmental Conservation, New York State Energy Research and development Authority, the Adirondack Lakes Survey Corporation, the U.S. Geological Survey, Syracuse University, Cornell University, SUNY College of Environmental Science and Forestry and Rensselaer Polytechnic Institute.

Table 3. Qualitative evaluation rating for the Adirondack region of New York.

1. Well-documented impacts to a particular ecosystem function or service: yes	
a.	impacts (specify): soil and surface water acidification; decreases in diversity in aquatic biota; possible impacts to red spruce and sugar maple
b.	level of degradation (specify severe, moderate, mild): severe
c.	importance of atmospheric deposition source (specify % and other sources): virtually 100%; some inputs of naturally occurring organic acids
2. Quantifiable endpoints (also specify data sources, if possible)	
A	ecological (specify): soil and surface water acidification
B	economic (specify): loss of fisheries; possible loss of tree species
3. Available monetary values for at least some endpoints (if available): Yes from RFF study	
4. Take advantage of existing initiatives to maximize use of available resources, avoid redundant research, and demonstrate multiple applications of ongoing project; yes – much work is going on in the Adirondacks; it would be good to take advantage of the RFF study	

Catskills – Goodale

The Catskill region covers approximately 5000 km² of southeast New York and supplies 90% of New York City's fresh water. The Catskill Mountains consist of broad peaks up to ~1200 m elevation formed as erosional remnants of an uplifted sedimentary delta. Northern hardwood forests cover most of the region, with some mixed oak at low elevations and mixed spruce-fir at the highest elevations. Atmospheric deposition is essentially the only source of N to these forests, with rates of N deposition among the highest in the U.S.: concentrations of inorganic N in precipitation average ~0.4-0.5 mg/L, and rates of wet + dry N deposition average 10-13 kg ha⁻¹ y⁻¹ (NADP, Lovett et al. 2000). Mean nitrate-N concentrations in 39 Catskill streams range from 0.03 to 0.51 mg/L and average 0.12 mg/L; peak nitrate-N concentrations in spring can exceed 0.7 mg/L (Lovett et al. 2000). If forest ecosystems were not accumulating and denitrifying the nitrogen received in deposition, stream nitrate concentrations might be expected to average ~1-3 mg/L (assuming that all N from deposition passed through the system, and 1/3 to 1/2 of precipitation is lost to evapotranspiration). Stream nitrate concentrations following disturbances can be quite high, due to continued soil N mineralization and lack of plant uptake. Following an experimental clear-cut, stream nitrate-N concentrations averaged 2-4 mg/L and peaked at 19.6 mg/L, or twice the EPA standard (10 mg/L) (Burns & Murdoch, in press). The particularly large response to disturbance by these forests relative to harvests elsewhere in the U.S. may reflect the long-term accumulation of atmospheric N in these forest soils.

New York City presently avoids EPA filtration requirements for drinking water. Water treatment consists of chlorination, fluorination, and treatment with orthophosphate (to reduce dissolution of lead from pipes) and sodium hydroxide to increase water pH. Nitrate-N concentrations in drinking water from the Catskill/Delaware system average 0.19 mg/L, and range from 0.10 – 0.89 mg/L (NYC DEP 2003). Regulation of non-point source pollution is focused on phosphorus, with several reservoirs exceeding their Total Maximum Daily Loads (TMDL).

Active research groups include:

U.S. Geological Survey – New York District, Watersheds Research Section, Troy, NY
Institute of Ecosystem Studies, Millbrook, NY
National Atmospheric Deposition Program: <http://nadp.sws.uiuc.edu/>

Sources:

Southern Appalachian Mountains – Driscoll

The southern Appalachian region of the U.S. includes approximately 35 million acres from northeastern Alabama to West Virginia and Virginia. This region receives elevated inputs of atmospheric sulfur and nitrogen deposition. Bedrock geology of the Southeast is more variable than that on the Northeast and includes shales and metabasalts as well as granites and quartzites. Surficial deposits are much older than the glaciated Northeast. Soils in high elevation sensitive areas are typically shallow, acidic and adsorb inputs of sulfate. Acid-sensitive surface waters of the Southern Appalachian region are generally limited to low-order or headwater streams; lakes are rare.

The southern Appalachian region includes Class I wilderness areas, such as the Great Smoky Mountain National Park and the Shenandoah National Park. This region includes many air quality related values, such as forest ecosystems, stream ecosystems, and vistas. Air quality issues of concern from the region include visibility, acidic deposition and ground-level ozone. Ecological effects of these air quality issues include acidic deposition to forest ecosystems, ozone damage to terrestrial resources, acidic deposition to aquatic ecosystems and visibility impairment.

The economy of the southern Appalachians is highly dependent on the natural resources of the region.

There have been several assessments of the effects of acidic deposition on the southern Appalachian mountain region (Cosby et al. 1991; Elwood et al. 1991). An important recent initiative was the Southern Appalachian Mountain Initiative (SAMI). The objective of SAMI is to identify air pollution effects in the southern Appalachian region, particularly Class I wilderness areas, and to make recommendations to mitigate these impacts. SAMI is a multi-institution, multi-stakeholder initiative (<http://www.epa.gov/region4/programs/cbep/saaa.html>).

There are many ongoing research activities and groups on effects of air pollution on resources of the southern Appalachian mountains, including Oak Ridge National Laboratory, the U.S. Park Service, the U.S. Forest Service, the U.S. Geological Survey, and the University of Virginia.

Table 4. Qualitative evaluation rating for the Southern Appalachian Mountains.

1. Well-documented impacts to a particular ecosystem function or service:	
yes	
a.	impacts (specify): soil and surface water acidification; decreases in diversity in aquatic biota; possible impacts to tree species
b.	level of degradation (specify severe, moderate, mild): severe
c.	importance of atmospheric deposition source (specify % and other sources): virtually 100%; some limited inputs sulfur from local mineral deposits
2. Quantifiable endpoints (also specify data sources, if possible)	
a	ecological (specify): soil and surface water acidification
b	economic (specify): loss of fisheries; possible loss of tree species

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3.	Available monetary values for at least some endpoints (if available): Not sure possibly from the SAMI study
4.	Take advantage of existing initiatives to maximize use of available resources, avoid redundant research, and demonstrate multiple applications of ongoing project; yes – much work is going on in the southern Appalachian region; it would be good to take advantage of the SAMI study

Everglades – Stahl

The Everglades and associated Everglades National Park (ENP) is a diverse aquatic ecosystem in southern Florida, USA covering more than 100 km². Despite the absence of major industrial point sources of contamination, the water, sediments and numerous biota of the ENP are known to contain elevated levels of mercury (Kang *et al.* 2000). One main pathway of mercury to the ENP is through atmospheric deposition, stemming from far field sources such as electrical power generating facilities. Upwards of 30 ng / m² (total Hg, wet + dry deposition) is estimated to fall in the ENP area (Schuster *et al.* 2002). The deposition of Hg has lead to elevated levels of mercury in fish species, and reductions in some populations of piscivorous birds (Sepulveda *et al.* 1999).

Table 5. Qualitative evaluation rating for the Everglades National Park.

1. Well-documented impacts to a particular ecosystem function or service:	
yes	
a.	impacts (specify): reduction in wading bird populations
b.	level of degradation (specify severe, moderate, mild): moderate
c.	importance of atmospheric deposition source (specify % and other sources): estimated low is 20%, estimated high of 80%
2. Quantifiable endpoints (also specify data sources, if possible)	
a	ecological (specify): contamination of food web with mercury; reduction in wading bird population
b	economic (specify); TBD
3. Available monetary values for at least some endpoints (if available):	
Likely	
4. Take advantage of existing initiatives to maximize use of available resources, avoid redundant research, and demonstrate multiple applications of ongoing project;	yes – national thrust on mercury emissions

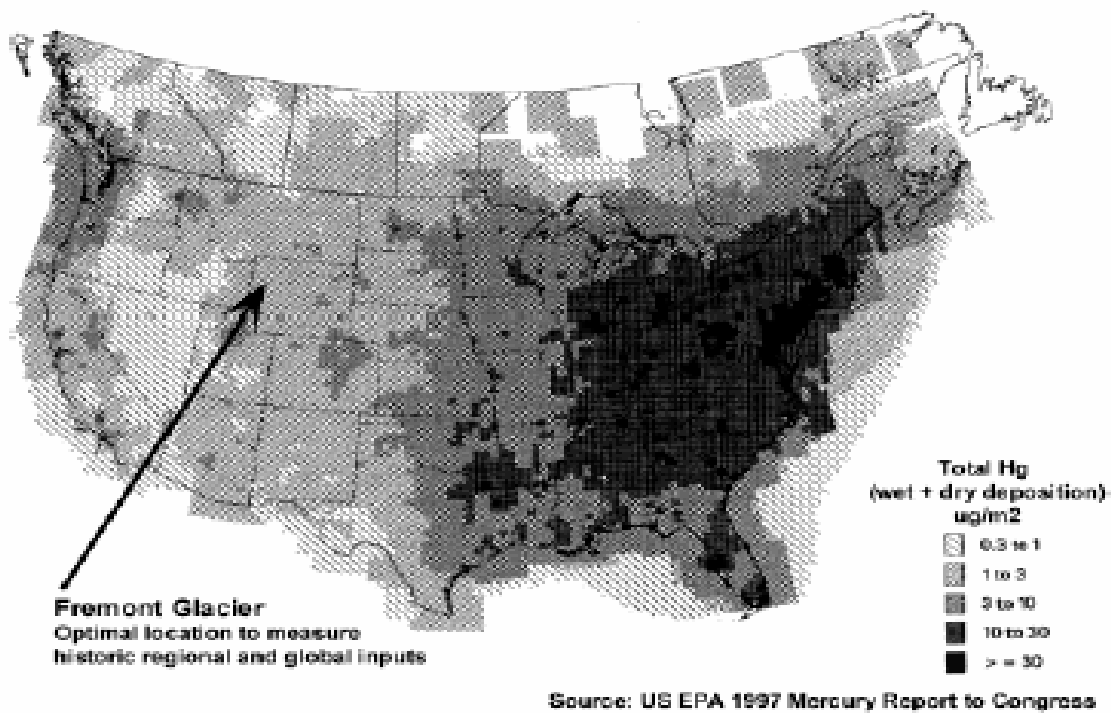


FIGURE 2. Location of the Upper Fremont Glacier showing very little impact from upwind local sources of atmospheric Hg.

From (Schuster *et al.* 2002)

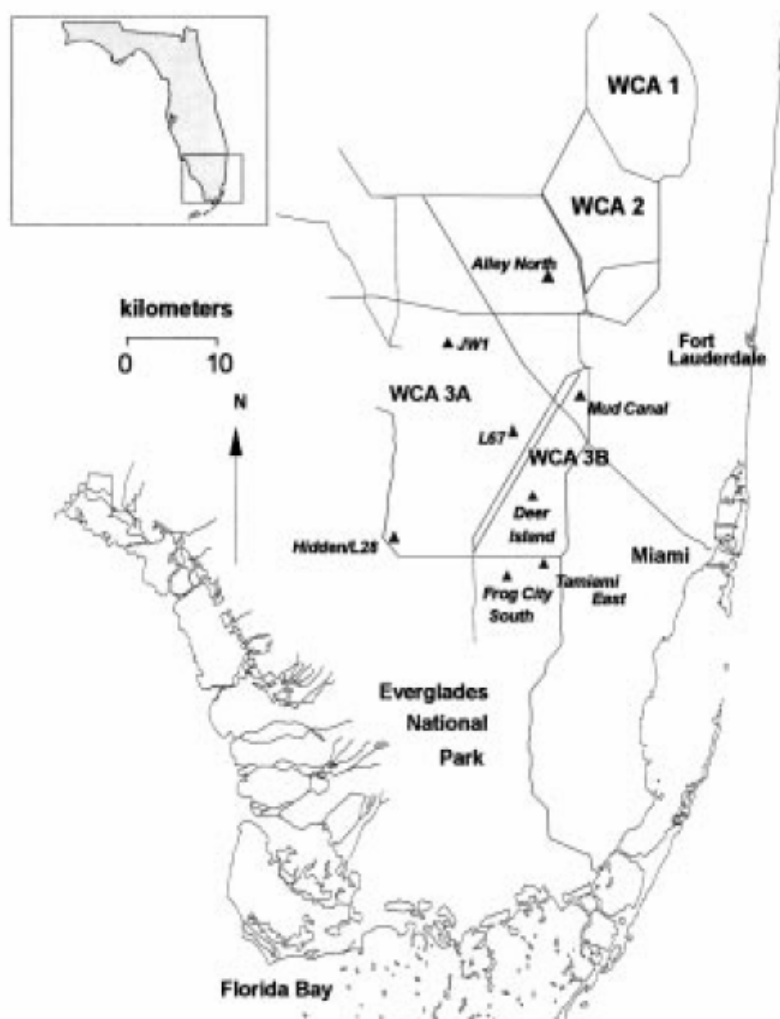


Fig. 1. Map of the study area in southern Florida, showing locations of colonies sampled (triangles) in Water Conservation Area 3 in relation to water management boundaries and areas of major habitation.

Rockies or Sierras – Boyer

Chesapeake Bay – Castro

Waquoit – Boyer

Question 20 – Harrison

Question 20. Does the Council support the plan for a feasibility analysis for a hedonic property study for valuing the effects of nitrogen deposition/eutrophication effects in the Chesapeake Bay region, with the idea that these results might complement the Waquoit Bay analysis?

The purpose of the Chesapeake Bay Property Value Feasibility Study (Markowski *et al.*, 2003) (Feasibility Study) is to investigate the possibility of using a hedonic analysis of coastal area property values to estimate the benefits to waterfront and near-water front homeowners of reductions in atmospheric nitrogen deposition associated with the Clean Air Act.

The premise of the proposed Feasibility Study that changes in coastal area water quality can be ascribed primarily to fluctuations in atmospheric nitrogen deposition is tenuous. Pearl (1993) estimated that between 10 and 50 percent of anthropogenic nitrogen inputs to coastal estuaries come from atmospheric deposition. However, more recent evaluations (Carpenter *et al.*, 1998; Boyer *et al.*, 2002; Driscoll *et al.*, 2003) suggest that this range may be high and, in fact, submit that eutrophic conditions observed in northeastern coastal areas stem more from non-atmospheric rather than atmospheric sources of nitrogen. In particular, Driscoll *et al.* (2003) found that atmospheric deposition to New York and New England estuaries accounted for only 14 percent to 35 percent. Non-atmospheric nitrogen sources contributed considerably more to the eutrophic conditions of the estuaries (wastewater effluent, 36 to 81 percent; runoff from agricultural lands, 4 to 20 percent; run off from urban lands, less than 1 to 20 percent; and runoff from forest lands, less than 1 to 5 percent). Consequently, while it is recognized that atmospheric nitrogen deposition contributes to coastal area eutrophication, its contribution would be overshadowed by non-atmospheric deposition sources to such an extent that any singular effect of atmospheric deposition would be difficult to ascribe to changes to waterfront and near waterfront property values.

A second problem of the proposed Feasibility Study concerns the use of a nutrient deposition/eutrophication water quality model with hedonic property value studies in general. According to Leggett and Bockstael (2000), there is an absence in the environmental literature of hedonic studies dealing with water quality due to the fact that many water quality indices measure pollutants that are impractical for homeowners to observe or that do not directly impair the enjoyment individuals derive from their waterfront homes. In particular, Leggett and Bockstael (2000) specifically note three indices (dissolved oxygen, phosphorus, and nitrogen) commonly used to measure water quality that are normally obscure to homeowners. Of the three, nitrogen is recognized as the major limiting factor of primary productivity and most responsible for the process of eutrophication of coastal waters such as the Chesapeake Bay and Waquoit Bay (Ryther and Dunstan, 1971; Carpenter *et al.*, 1996; Howarth *et al.*, 1996). High nitrogen levels can have adverse impacts on coastal area aquatic plants and animals, but, according to Leggett and Bockstael (2000), variations in such nutrient concentrations tend to go unnoticed by homeowners unless the high nutrient levels combine with the requisite chemical, biological, and physical conditions to cause episodic algal blooms and/or fish kills.

In an attempt to address this problem, the Feasibility Study suggests that three water quality

indicators (continuous near-shore chlorophyll *a* measurements, coupled with annual measurements of near-shore submerged aquatic vegetation and periodic observations of macroalgal blooms) be used as a surrogate for nitrogen deposition. The proposed continuous measurement of chlorophyll *a*, which is a direct quantitative measure of primary productivity (National Research Council, 2000) would be an appropriate indicator to track fluctuating eutrophic conditions (Whittaker, 1972; Brewer 1979), and, therefore, nitrogen deposition in coastal waters. However, the Feasibility Study's proposed water quality indices would not eliminate the problem of an unaware shoreline and near-shore populace of the quality of the water. It is not at all clear from the Feasibility Study proposal how an only once per year evaluation of near-shore submerged vegetation and a sporadic reporting of algal blooms by volunteer residents would be sufficient to establish the requisite observable water quality impacts necessary to conduct a robust shoreline property value analysis.

Finally, the Feasibility Study indicates that time series ecological data would not be collected since such data are less important to a property value analysis than are high quality ecological data on variation across space. This is supported with the statement in the Feasibility Study that since spatial pattern of nitrogen sources and flushing environments do not change dramatically through time, the spatial pattern of eutrophication is also likely to be somewhat stable from one year to the next. While this rationale has some merit, the inclusion of time series data would make the proposed water quality investigation of the Feasibility Study much more robust (Pearl, Aguilar and Fogel, 1997) and would be consistent with the need to demonstrate how variations in nitrogen deposition impact coastal waters eutrophic conditions. This, in turn, could provide a much clearer understanding of how the varying eutrophic conditions might impact shoreline and near shore property values.

Given the above, the Ecological Effects Subcommittee recommends that the Council not proceed with the proposed Feasibility Study. Rather, it is recommended that alternative case studies be explored that could be better correlated with atmospheric nitrogen deposition.

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